MARTIN MARIETTA ASTRO SPACE

POST OFFICE BOX 800
PRINCETON, NEW JERSEY 08543-0800
TELEPHONE (609) 490-4660
FAX (609) 490-2211

18 March 1994

RECEIVED

MAR 2 1 1994

FCC - MAIL ROOM

Office of the Secretary
CC Docket No. 92-297
Federal Communications Commission
1919 M Street N.W.
Washington, DC 20554

Reference: CC Docket No. 92-297

In accordance with the provisions in Article IV.B.11 of the above referenced Docket, Martin Marietta Astro Space hereby applies for membership in the Advisory Committee that is planned to be chartered to negotiate the technical regulations concerning the redesignation of the 27.5 to 29.5 GHz frequency spectrum band to shared use between satellite uplink and terrestrial point-to-multipoint service providers.

In accordance with the provisions of said article, the required application information is as follows:

(a) name of applicant and description of interests the entity will represent

The name of the applicant is: Martin Marietta Astro Space

Description of interests that the entity will represent:

Martin Marietta Astro Space will represent our own interests as a spacecraft manufacturer and the interests of our present and potential customers which are studying and planning satellite services using this frequency band.

(b) evidence that the applicant is authorized to represent parties related to the interests the entity proposes to represent.

Martin Marietta Astro Space would represent its own significant business interests.

In addition, Martin Marietta Astro Space is in process of discussions with a potential customer for a commercial satellite network venture that might employ a fixed service satellite uplink in the subject frequency band. Because of commercial reasons, we cannot publicly identify this customer, but would be glad to provide such privileged information to the FCC under separate cover if requested.

(c) a written commitment that the applicant or nominee shall actively participate in good faith in the development of the rules under consideration

Martin Marietta Astro Space management is committed to active participation in good faith in the development of the rules under consideration.

No. of Copies rec'd 0
List ABCDE

(d) the reasons that the entities specified in paragraph 8 do not adequately represent the interests of the entity submitting the application

Martin Marietta Astro Space is one of the world's foremost communications satellite manufacturers, having to date built and successfully launched 39 civilian communications satellites for 15 different customers, including the NASA's Advanced Technology Satellite (ACTS) which operates in the subject frequency band. The ACTS program has, among its goals, the task of evaluating the use of the subject frequency band not only by extended propagation studies conducted at many earth locations over the life of the satellite, but also in extended experimental demonstrations in actual operational environments. Martin Marietta Astro Space recently published a technical paper (AIAA-94-0939-CP, copy enclosed) describing a possible satellite configuration employing ACTS technologies and frequencies to complement the capabilities, improve public access and correct some shortcomings of the terrestrial based architectures currently proposed for the National Information Infrastructure a.k.a. "Information Superhighway". This paper was presented earlier this month at the 15th International Communications Satellite Systems Conference in San Diego. We feel that any reassignment of the subject frequency band to other services while the ACTS data is still being collected and before the operational results have been fully assessed and communicated to potential service providers may be premature and not in Martin Marietta's or the public interest.

The interests specified in paragraph 8 include four entities (American Mobile Satellite Corporation, TRW Inc., Hughes Space and Communications Company, and Loral/Qualcom) who are direct competitors of Martin Marietta Astro Space or are partially or wholly owned by such competitors (see for example the enclosed July 20, 1993 New York Times article).

For all the above reasons we do not believe that the listed entities would adequately represent Martin Marietta or our present or potential customer's interests in this matter.

Jack W. Hugus
General Manager, Business Development

cc.

Ms. Susan Magnotti
Domestic Radio Branch - Room 6310
2025 M Street N.W.
Washington, DC 20554

OPERATIONAL SATELLITES USING ACTS TECHNOLOGY

Eduardo L. Elizondo*, Joseph F. Balcewicz†, Alan Stern, Osvaldo Regalado, Terry Drackett, and Steve Chulik†

Martin Marietta Astro Space
PO Box 800
Princeton, NJ 08543

Abstract

The NASA ACTS spacecraft has demonstrated several unique capabilities including adaptive on-demand capacity, compatibility with extremely small aperture terminals, message switched spot-to-spot communications and use of an uncrowded area of the frequency spectrum. A possible configuration for a large operational satellite exploiting these technologies is described. Such a satellite could satisfy, at least in part, the increasing global demand for data communications capacity and interconnectivity and could serve as a vital link in the proposed US National "Information Superhighway".

Introduction

Information is regarded today as a fundamental factor of production, alongside capital and labor. According to studies by personnel of the World Bank, the information sector accounted for one-third to one-half of the Gross Domestic Product (GDP) and of employment in the OECD‡ countries in the 1980s, and is expected to reach 60% for the European Community in the year 2000[1]. Information also accounts for a substantial proportion of GDP in the newly industrialized economies and the modern sectors of less developed countries. Telecommunications is now widely considered to be a strategic investment to maintain and develop competitive advantage at all levels - national, regional and company/organization. Countries, companies and organizations which lack access to modern telecommunication systems cannot effectively participate in the global economy. This increasing information intensity has produced an unabated demand for better, higher capacity, more varied and less costly communications services.

In the United States, the Clinton administration has proposed the creation of a National Information Infrastructure (NII), also known as the Information Superhighway. Most discussions to date on the implementation of such a resource have described terrestrial based transmission media; usually some combination of optical fibers, coaxial cables and twisted pairs. In fact, we are now witnessing the alliances of cable companies and regional telephone and data carriers aimed at "cabling up" various sections of the continental US.

We believe that this "plan" has several deficiencies that the judicious use of satellites can overcome. In summary, satellites can:

- provide "equal access" to the NII, especially to citizens in remote areas of all 50 states who, for economic reasons, may never be served by fiber;
- provide an alternate transmission service for many users that would lead to competitive pricing structures; and
- provide an independent transmission medium to restore service in the event of natural and man-made disasters, and extend service to rapidly developing areas until they can be connected into the terrestrial structure.

Satellite payload configurations that are based on the advanced communication technologies incorporated into NASA's Advanced Communication Technology Satellite (ACTS) are especially well-suited to satisfying these mission requirements.

A Candidate Payload Design

For the purpose of this study we configure a satellite payload that is a combination of "Operational ACTS" payloads that have been previously

*Associate Fellow AIAA, †Member AIAA
‡Organization for Economic Cooperation and Development

generated during NASA-funded studies[2,3]. The candidate payload for this hypothetical "ISAT" satellite consists of:

- A high data rate (HDR) subsystem capable of simultaneously sending data to and from 20 geographic locations selected out of 200 possible beams at rates up to several Gb/s using IF Switch Matrix technology. This service could be used for network trunking, interconnection of supercomputers, transmission of large data files such as images, and cable backup and restoration.

- A low burst rate (LBR) subsystem serving all 50 states with scanning spot beams and on-board demodulation/remodulation using ACTS Baseband Processor (BBP) technology. This payload would provide service at T1 rates to 2,400 VSAT ground terminals simultaneously. This service would primarily be used for business communications purposes.

- A second LBR subsystem also serving all 50 states. This payload would provide a lower rate data transmission service serving extremely small aperture terminals. Fixed receive spot beams and scanning transmit spot beams would provide service connectivity for rates up to 20 kb/s with earth terminal apertures of about 0.6m in diameter. ACTS BBP technology would be augmented with bulk demodulators to efficiently process up to 30,000 simultaneous users. These services would be provided primarily to individual users.

High Data Rate (HDR) Subsystem

The HDR subsystem design is based on a similar system discussed in Ref. 2. The block diagram of the basic payload is shown in Figure 1. The payload size is increased by a factor of 2 from that of Ref. 2 to provide simultaneous operation of 20 switched uplink and 20 switched downlink beams out of a total of 200 beam positions. The key communications link parameters for this service are shown in Table 1.

The available 2.5 GHz bandwidth may be divided into either four 600 MHz channels, two 600 MHz channels and one 1200 MHz channel, or two 1200 MHz channels. These bandwidths can support the following coded transmission rates:

Satellite:

- Uplink: 30 GHz
  Four 600 MHz Channels (or Two 1200 MHz Channels)
  2400 MHz Total Bandwidth
  Single Linear Polarization
  20 Switched Beams, 200 Beam Positions With Spatial Frequency Reuse

- Downlink: 20 GHz
  Four 600 MHz Channels (or Two 1200 MHz Channels)
  2400 MHz Total Bandwidth
  Single Linear Polarization
  20 Switched Beams, 200 Beam Positions With Spatial Frequency Reuse

- TWTA Power Amplifier: 100 Watts
- Transmit Antenna Diameter: 3.3 m
- EIRP: 67.9 dBW
- Receiver Noise Figure: 3.5 dB
- Receive Antenna Diameter: 2.3 m
- G/T: 19.3 dB/K
- Throughput: 1000 Mb/s per Channel x 4 Channels x 20 Beams = 80,000 Mb/s total (QPSK, Rate 3/4 Convolutional Code)

Ground Station:

- Antenna Diameter: 5 m
- Transmitter: 400 Watts
- EIRP: 87.0 dBW
- Receiver Noise Figure: 3.5 dB
- G/T: 30.5 dB/K
- Rain Degradation Allowance
  Uplink: 15 dB
  Downlink: 8 dB
- Data Rates (QPSK, Rate 3/4 Convolutional Code):
  Uplink: 1000 Mb/s burst
  Downlink: 1000 Mb/s burst
  Throughput: 1000 Mb/s burst
- BER 10^{-6}

Table 1. Key Communications Link Parameters for HDR Service

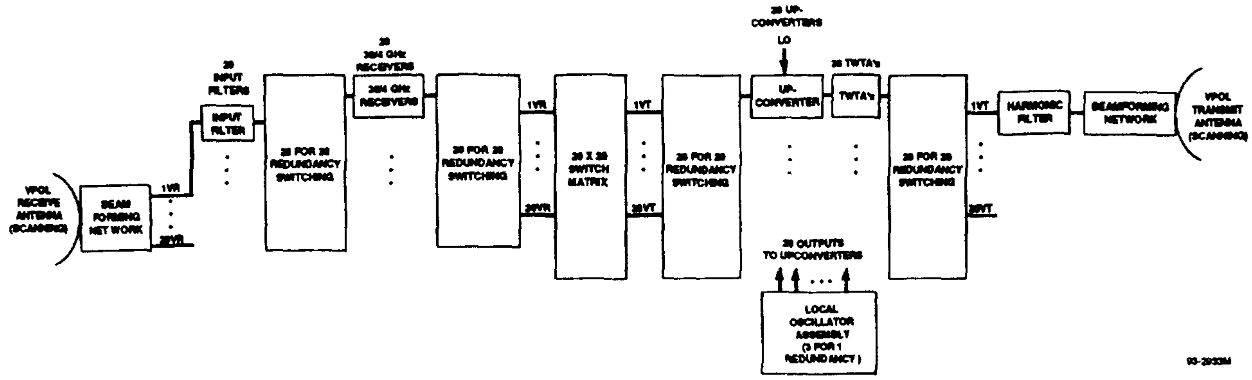


Fig. 1. High Data Rate (HDR) Subsystem Block Diagram

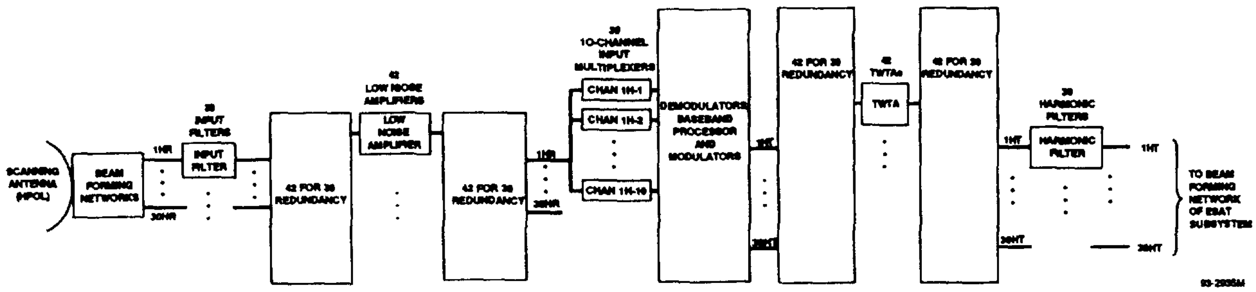


Fig. 2. T1 VSAT LBR Subsystem Block Diagram

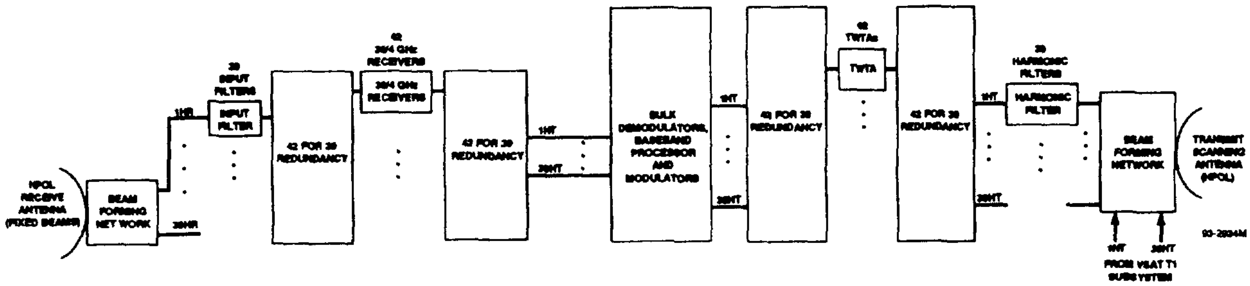


Fig. 3. Extremely Small Aperture Terminal (ESAT) LBR Subsystem Block Diagram

Modulation	Data Rate (Gb/s)* 600 MHz Channel	1200 MHz Channel
Binary PSK	0.5	1.0
QPSK	1.0	1.9
8-PSK	1.4	2.9
16-PSK	1.9	3.8

*assumes 1.6 b/s/Hz for QPSK

As an applications example, consider the case where we wish to transmit an image file of a 160 km x 160 km surface area that has 1 meter resolution in 4 spectral bands and digitized to 10 bits. This represents an extremely large data file of approximately $(160{,}000)^2 \times 4 \times 10 \approx 10^{12}$ bits (1 Tbit). Even at a 3.8 Gb/s coded (2.85 Gb/s pre-coding) data rate this imagery will require 6 minutes to transmit.

This HDR service uses nearly all the Ka-band bandwidth available on one polarization (the LBR subsystems will use the orthogonal polarization). Since this bandwidth provides only two-to-four HDR channels, the 20 simultaneous links will have to employ frequency reuse. Frequency assignments will be made on the basis of beam-to-beam isolation.

The satellite TWTA feeding each of the 20 links is assumed to be 100 Watts (a modest enhancement of flight qualified 60 Watt Ka-band TWTAs currently available from a number of manufacturers). This increase in TWTA power corresponds to a 7 dB link improvement over that of Ref. 2. This could permit the use of 16-ary modulation, which requires an E_b/N_0 approximately 7.8 dB higher than QPSK, to obtain data rates of 3 Gb/s per link (assuming the development of suitable ground modems and a corresponding increase in ground station EIRP).

The subsystem mass and power estimates are presented in Table 2. These estimates are conservatively based on current TWTA performance and ACTS technology and have not assumed any potential technology improvements to significantly reduce on-board equipment power and weight.

Component	Qty	Qty ON	Unit Mass (kg)	Total Mass (kg)	Unit Pwr (W)	Total Pwr (W)
3.3m Transmit Antenna	1		38.5	39		0
2.3m Receive Antenna	1		21.3	21		0
Feed Assembly & BFNs	2	2	178.2	356	144	288
Input Filter	20		0.1	2		0
30/4 GHz Receiver	28	20	2.0	55	4	86
IF Switch Matrix & Control	1	1	29.0	29	208	208
Upconverter	28	20	0.7	19	2	30
100 Watt TWTA	28	20	5.9	165	250	5000
Local Oscillator Assembly	1	1	2.0	2	7	7
Harmonic Filter	20		0.0	1		0
Waveguide "R" Switch	48		0.1	7		0
Coaxial "T" Switch	48		0.2	9		0
Waveguide & Coax	1		10.9	11		0
				------		------
HDR Subsystem Total				715		5619

Table 2. HDR Subsystem Payload Equipment

T1 VSAT Low Burst Rate (LBR) Subsystem

The T1 VSAT LBR subsystem architecture is again based on Ref. 2. The basic block diagram is shown in Figure 2. As configured, the T1 payload of Ref. 2 requires 400 MHz to service 800 terminals simultaneously at the T1 data rate (1.544 Mb/s). For this study this payload size is increased by a factor of three to service a total of 2,400 terminals simultaneously. The payload utilizes a 1.5m spacecraft fixed beam receive antenna and a 1.6m scanning beam transmit antenna, which is shared with the ESAT LBR Subsystem. The key link parameters for this service are listed in Table 3.

The T1 VSAT service will occupy 1.2 GHz of the $\approx$ 2.5 GHz bandwidth available on the polarization orthogonal to that used for the HDR service. The subsystem mass and power estimates are presented in Table 4, again assuming current TWTA and ACTS technology.

Satellite:	
• Uplink:	30 GHz Ten 40 MHz Channels per Beam (300 Channels Total), 1200 MHz Total Bandwidth Single Linear Polarization 30 Switched Beams, 100 Beam Positions
• Downlink:	20 GHz Three 400 MHz Channels per Beam (90 Channels Total), 1200 MHz Total Bandwidth Single Linear Polarization 30 Switched Beams, 100 Beam Positions
• TWTA Power Amplifier:	50 Watts
• Transmit Antenna Diameter:	1.5 m 0.7° Beamwidth
• EIRP:	63.0 dBW
• Receiver Noise Figure:	3.5 dB
• Receive Antenna Diameter:	1.6 m 0.7° Beamwidth
• G/T:	17.4 dB/K
• Throughput:	200 Mb/s per Downlink Channel x 3 Channels per Beam x 30 Beams = 18,000 Mb/s Total (QPSK, Rate 3/4 Convolutional Code)
Ground Station:	
• Antenna Diameter:	1.5 m
• Transmitter:	40 Watts
• EIRP:	66.6 dBW
• Receiver Noise Figure:	3.5 dB
• G/T:	19.6 dB/K
• Rain Degradation Allowance	
Uplink:	15 dB
Downlink:	8 dB
• Data Rates (QPSK, Rate 3/4 Convolutional Code)	
Uplink:	20 Mb/s TDMA Burst
Downlink:	200 Mb/s TDMA Burst
Throughput:	T1 (1.544 Mb/s)
• TDMA Frame Duration	1 ms
• BER	
Uplink:	10^{-7}
Downlink:	7×10^{-7}
• Number of Simultaneous Terminals Per Spacecraft:	2400

Table 3. Key Communications Link Parameters for T1 VSAT LBR Service

Component	Qty	Qty ON	Unit Mass (kg)	Total Mass (kg)	Unit Pwr (W)	Total Pwr (W)
1.6m Transmit Antenna	1		13.2	13		0
1.5m Receive Antenna	1		15.0	15		0
Feed Assembly & BFNs	2	2	171.9	344	160	320
Input Filter	30		0.1	3		0
30 GHz LNA	42	30	2.0	82	4	129
10-Channel Input Multiplexer	30		4.8	143		0
Baseband Processor	3	3	62.6	188	669	2007
50 Watt TWTA	42	30	3.2	133	125	3750
Harmonic Filter	30		0.0	1		0
Waveguide 'R' Switch	60		0.1	8		0
Coaxial 'T' Switch	60		0.2	11		0
Waveguide & Coax	1		27.2	27		0
				------		------
T1 VSAT Subsystem Total				968		6206

Table 4. T1 VSAT Subsystem Payload Equipment

Extremely Small Aperture Terminal (ESAT) LBR Subsystem

The ESAT subsystem architecture is derived from Ref. 3. The basic payload block diagram is shown in Figure 3. The basic ESAT payload of Ref. 3 requires 100 MHz to service 10,000 simultaneous users. For this study, this payload size has been increased by a factor of three to provide simultaneous service to 30,000 users at a 20 kb/s data rate per terminal. The service will occupy 300 MHz of the ≈ 2.5 GHz bandwidth available on the polarization orthogonal to that used for the HDR service. The key communications link parameters for this service are shown in Table 5.

The ESAT payload will share the spacecraft scanning beam transmit antenna with the T1 VSAT subsystem and will require a smaller (0.5m) diameter fixed beam receive antenna. The subsystem mass and power estimates are included in Table 6.

Satellite:

- Uplink: 30 GHz
  Three 100 MHz Channels With Spatial Frequency Reuse, 300 MHz Total Bandwidth
  30 Fixed Beams
  Single Linear Polarization
- Downlink: 20 GHz
  Three 100 MHz Channels With Spatial Frequency Reuse, 300 MHz Total Bandwidth
  30 Switched Beams, 100 Beam Positions
  Single Linear Polarization
- TWTA Power Amplifier: 50 Watts
- Transmit Antenna Diameter: 1.5 m (Shared With T1 VSAT Subsystem)
  0.7° Beamwidth
- EIRP: 63.0 dBW
- Receiver Noise Figure: 3.5 dB
- Receive Antenna Diameter: 0.5 m
  1.9° Beamwidth
- G/T: 7.6 dB/K
- Throughput: 20 Mb/s per Beam x 30 Beams = 600 Mb/s Total

Ground Station:

- Antenna Diameter: 0.6 m
- Transmitter: 2.5 Watts
- EIRP: 46.6 dBW
- Receiver Noise Figure: 4.0 dB
- G/T: 11.5 dB/K
- Rain Degradation Allowance
  Uplink: 15 dB
  Downlink: 8 dB
- Data Rates (QPSK, Rate 3/4 Convolutional Code):
  Uplink: 20 kb/s Continuous Transmission
  Downlink: 20 Mb/s TDMA Burst
  Throughput: 20 kb/s
- BER
  Uplink: 10^{-7}
  Downlink: 7×10^{-7}
- Number of Simultaneous Terminals Per Spacecraft: 30,000

Table 5. Key Communications Link Parameters for the ESAT Service

Component	Qty	Qty ON	Unit Mass (kg)	Total Mass (kg)	Unit Pwr (W)	Total Pwr (W)
0.5m Receive Antenna	1		1.4	1		0
Receive Feed Assembly & BFNs	1		14.5	15		0
Input Filter	30		0.1	3		0
30/4 GHz Receiver	42	30	2.0	82	4	129
Baseband Processor	3	3	56.2	169	667	2001
50 Watt TWTA	42	30	3.2	133	125	3750
Harmonic Filter	30		0.0	1		0
Waveguide "R" Switch	66		0.1	9		0
Coaxial "T" Switch	126		0.2	23		0
Waveguide & Coax	1		8.2	8		0
				------		------
ESAT Subsystem Total				444		5880

Table 6. ESAT LBR Subsystem Payload Equipment

Payload Totals

In summary, the ISAT satellite configured herein is equipped with:

- One 3.3m diameter transmit antenna
- One 2.3m diameter receive antenna
- One 1.5m diameter receive antenna
- One 1.6m diameter transmit antenna
- One 0.5m diameter receive antenna

The total payload mass and power summary is as follows:

Subsystem	Mass (kg)	DC Power (Watts)
HDR	715	5619
T1 LBR	968	6206
ESAT LBR	444	5880
	------	-------
Total	2127	17705

Spacecraft Accommodation

The larger "standard" communications satellites currently in production typically accommodate payloads in the 400 to 500 Kg mass and 4 to 6 kW power range. The proposed payload could be accommodated by a single much larger satellite or by a combination of "standard" satellites operating in complementary fashion, the decision based primarily on economic, schedule and risk management factors.

Single Satellite Accommodation

Accommodation of such a large payload on a single spacecraft poses a significant, though not insurmountable challenge. Our studies indicate that the ISAT mission could indeed be accommodated on a spacecraft "scaled up" from the Martin Marietta A2100 spacecraft bus. This spacecraft, conceptually shown in Figures 4a and 4b, is compatible with launch by a Titan IV (Figure 6). Salient characteristics of this spacecraft are shown in Table 7.

• Mission life:	15 years
• Structure Dimensions:	5.6m x 2.7m x 2.7m
• Solar Array:	GaAs Cells
Total Area:	156 m^2
EOL Output (Equinox)	21,500 W
• Batteries:	NiH
Total Number of Cells:	224
Cell Capacity:	110 AH
Total Capacity:	24,640 AH
Full Eclipse Capability	
Maximum DOD	< 80%
• Attitude Control:	3-Axis
Zero Momentum Using Reaction Wheels	
• Propulsion: Hydrazine Monopropellant	
Transfer Orbit Injection:	8 Arcjets
N/S Stationkkeping:	4 Arcjets
E/W Stationkeeping and Backup Attitude Control:	18 REAs
• Thermal Radiator:	Deployable
Total Radiator Area:	77 m^2
• Dry mass:	
Primary Structure	744 kg
Integration Hardware	242 kg
Mechanisms	42 kg
Attitude Control	54 kg
TT&C	44 kg
Propulsion	246 kg
Power (incl. batteries)	1268 kg
Harness	220 kg
Payload	2127 kg

Subtotal	4987 kg
Implementation Margin	249 kg
Pressurant	14 kg

Total Dry Mass w/Margin	5250 kg
Liftoff Mass	8620 kg

Table 7. Key ISAT Spacecraft Characteristics

Several mission scenarios have been investigated to determine methods of achieving geostationary orbit and different stationkeeping options. Options for the launcher injection orbit, the engines used for transfer from Low Earth Orbit (LEO) to Geostationary Orbit (GSO) and the engines used for North/South stationkeeping during the mission are listed in Table 8. The Liquid Apogee Engine considered is the enhanced hydrazine/nitrogen tetroxide bipropellant engine utilized in Martin Marietta Astro Space A2100 spacecraft bus. The Arcjet performance considered corresponds to projected enhancements to the hydrazine Arcjet thrusters flown on Telstar 4. Performance for ion and Stationary Plasma Thruster (SPT) engines are estimated based on current technology.

- Injection Orbits:
  - 185 km Circular Parking Orbit
  - Standard Geotransfer Orbit, 28° Inclination
  - Direct Geosynchronous Orbit (Using Centaur Upper Stage)
- On-Board Engine Alternatives for LEO to GEO Transfer:
  - One Liquid Apogee Engine (LAE)
  - Eight Arcjets
  - Eight Stationary Plasma Thrusters (SPTs)
  - Eight Ion Engines
- North/South Stationkeeping Engine Options:
  - Arcjets
  - Stationary Plasma Thrusters
  - Ion Thrusters

Table 8. Mission Options

All cases assume:

- Titan IV/SRMU launch vehicle[4]
- 15 year mission life
- ±0.1° N/S and E/W stationkeeping box
- A single mid-life orbit relocation at a 1°/day rate
- Spiral injection maneuver for all low thrust engine options (90% efficiency is assumed for spiral injection maneuvers due to inherently greater requirements for momentum offloading)

The resulting orbit injection maneuver times and dry

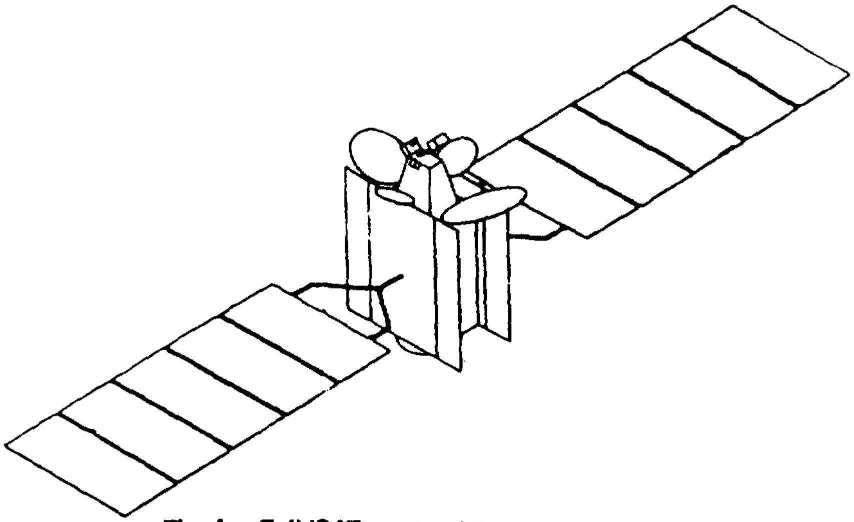


Fig. 4a. Full ISAT payload–In-orbit configuration

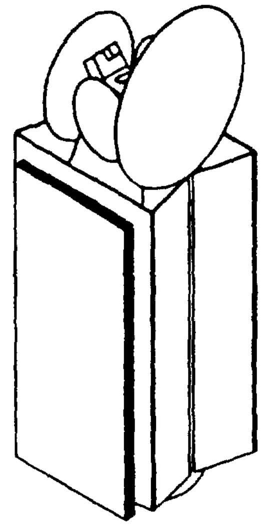


Fig. 4b. Full ISAT payload–
Launch configuration

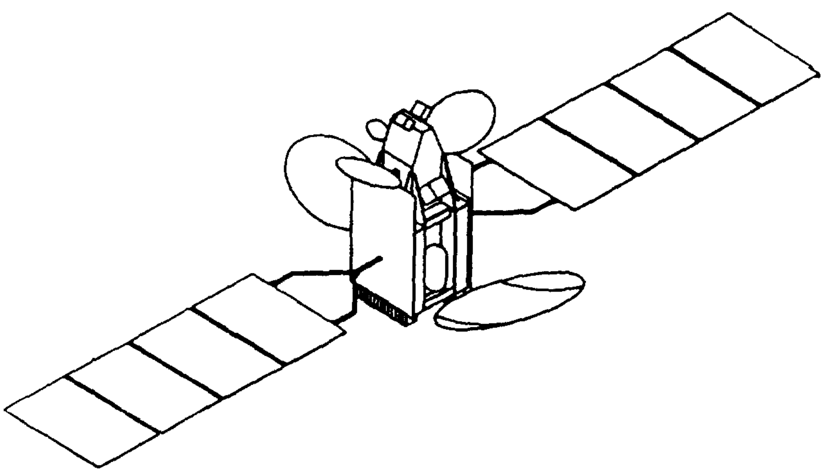


Fig. 5a. 20% ISAT payload– In-orbit configuration

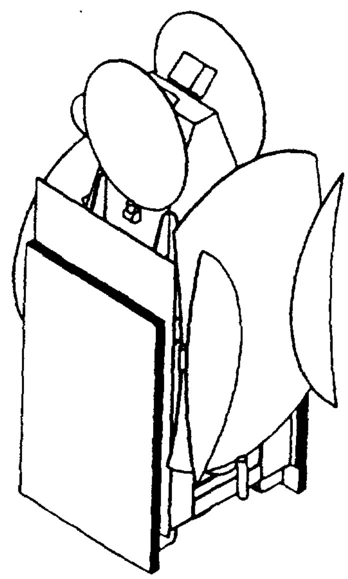


Fig. 5b. 20% ISAT payload–
Launch configuration

mass capabilities for the various mission options are summarized in Table 9. The results indicate that the optimum mission scenario (indicated by the boxed line in the Table) appears to be to launch into standard geostationary transfer orbit (GTO) and then inject into geosynchronous orbit utilizing multiple Arcjet thrusters. The use of eight Arcjet thrusters for injection has been assumed in this analysis, which is compatible with the available solar array power. Arcjets are also utilized for North/South stationkeeping. This mission scenario is compatible with the ISAT spacecraft dry mass estimate presented here and achieves injection to mission orbit in a reasonable time (85 days).

TITAN IV Injection Orbit	Mass to Injection (kg)	LEO to GEO Engine Type	Isp (sec)	Mass to GSO (Kg)	Injection Time (days)	NSSK Engines Used	On-Orbit Dry Mass (kg)
185 km Parking	21640	Ion	3200	17546	1900	Ion	16101
185 km Parking	21640	SPT	1600	14226	1720	SPT	12773
185 km Parking	21640	Arcjet	650	7706	500	Arcjet	6491
185 km Parking	21640	LAE	328	5707	0.5	Arcjet	4807
GTO	8620	Ion	3200	8073	254	Ion	7409
GTO	8620	SPT	1600	7561	246	SPT	6789
GTO	8620	Arcjet	650	6243	85	Arcjet	5258
GTO	8620	LAE	328	4848	0.1	Arcjet	4084
Direct GSO (w/Centaur)	5220	-	-	5220	-	Ion	4790
Direct GSO (w/Centaur)	5220	-	-	5220	-	SPT	4687
Direct GSO (w/Centaur)	5220	-	-	5220	-	Arcjet	4397

Table 9. Mission Analysis Summary

Multiple Satellite Accommodation

Distributing the candidate payload among several satellites permits the use of satellite buses in current production, with consequent reduction of schedule and non-recurring costs, as well as allowing the use of other launchers such as Atlas and Ariane. A system cost tradeoff has not been performed, but it is likely that the total program costs for the multiple satellite approach will be greater than that of the single satellite approach when one includes the launcher costs.

One approach is to build 5 or 6 identical spacecraft, each carrying about one fifth of the total payload. Such a satellite, conceptually shown in Figures 5a and 5b, is well within the capabilities of contemporary communications satellite buses and only presents a challenge to the designer to accommodate the multiple antenna farm required for the composite mission. One advantage of this solution is that service is provided to all 3 classes of users from each satellite; this permits the 5 or 6 satellites to serve as backups to one another and would also allow launches to be scheduled according to service demand. A major disadvantage is that each satellite would need to carry the full antenna farm, which represents a mass and cost penalty on each satellite.

An alternate approach is to split the mission into three satellite pairs, each pair dedicated to a separate class of service. Thus two satellites would perform the HDR mission, two satellites the T1 VSAT mission and two satellites the ESAT mission. This configuration has the advantage of reduced complexity in each satellite, since each satellite would only carry the payload and antennas corresponding to the individual mission class. Three different satellite designs would be required, one for each mission. An operational disadvantage of this configuration is that full service to the three classes of users would not be available until three operational satellites, one of each type, are launched.

Conclusion

This paper has attempted to describe several approaches to high capacity operational communications satellites employing advanced technologies that have been developed for the ACTS satellite, including wideband Ka-Band RF components, scanning spot beam antennas, and on-board processing, storage and routing of data. Such satellites are capable of providing new classes of services to a potentially large segment of new users. In particular, the application of ACTS technologies appears to be well suited to complement the capabilities, improve public access and correct some shortcomings of the land based architectures currently proposed for the National Information Infrastructure, a.k.a. the Information Superhighway.

Currently there is a 2.5 GHz of uplink and downlink bandwidth allocated to satellite services at Ka-band. It is important that this spectrum not be re-allocated to other uses until the role of high capacity satellite systems have had a sufficient period of time to develop. Also it is important that any data transmission protocols developed as standards for the National Information Infrastructure retain compatibility with transmission delays to and from geosynchronous orbit. Only thus will the interconnectivity benefits that can only be provided by satellites be realized.

References

1. B. Wellenius, and others, "Telecommunications - World Bank Experience and Strategy", World Bank Discussion Paper No. 192, March 1993, The World Bank, Washington, DC.

2. R. Gedney, D. Wright, J. Balombin, P. Sohn, W. Cashman, A. Stern, L. Golding and L. Palmer, "Operational Uses of ACTS Technology". AIAA-92-1964-CP, Proceedings of the 14th International Communications Satellite Systems Conference, March 1992, Washington, DC.

3. A. Stern and D. Wright, "Spacecraft Designs for VSAT Networks". AIAA-90-0895-CP, Proceedings of the 13th International Communications Satellite Systems Conference, March 1990, Washington DC.

4. S. Isakowitz, "International Reference Guide to Space Launch Systems", 1991 Edition, AIAA, Washington, DC.

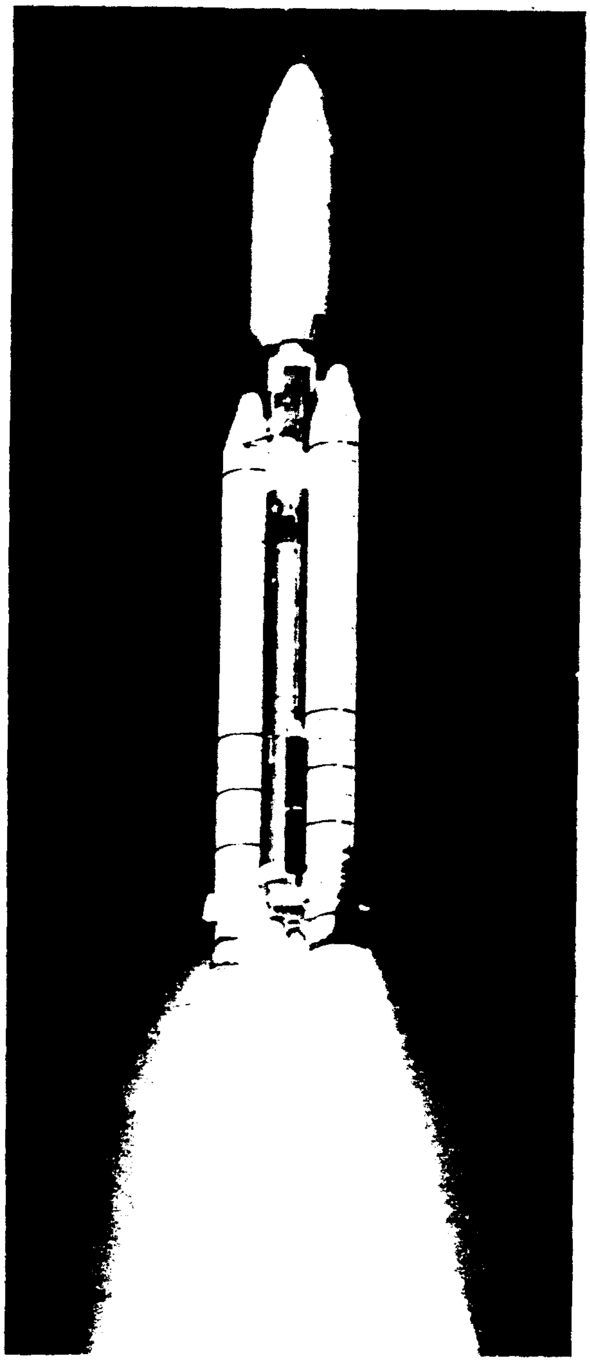


Fig. 6. Titan IV launch vehicle

isks of Denying Rivers Their Flood Plains

development away from the flood plain, preserving or restoring its ecosystems and letting water flow as freely as possible so that natural flood-control mechanisms can work.

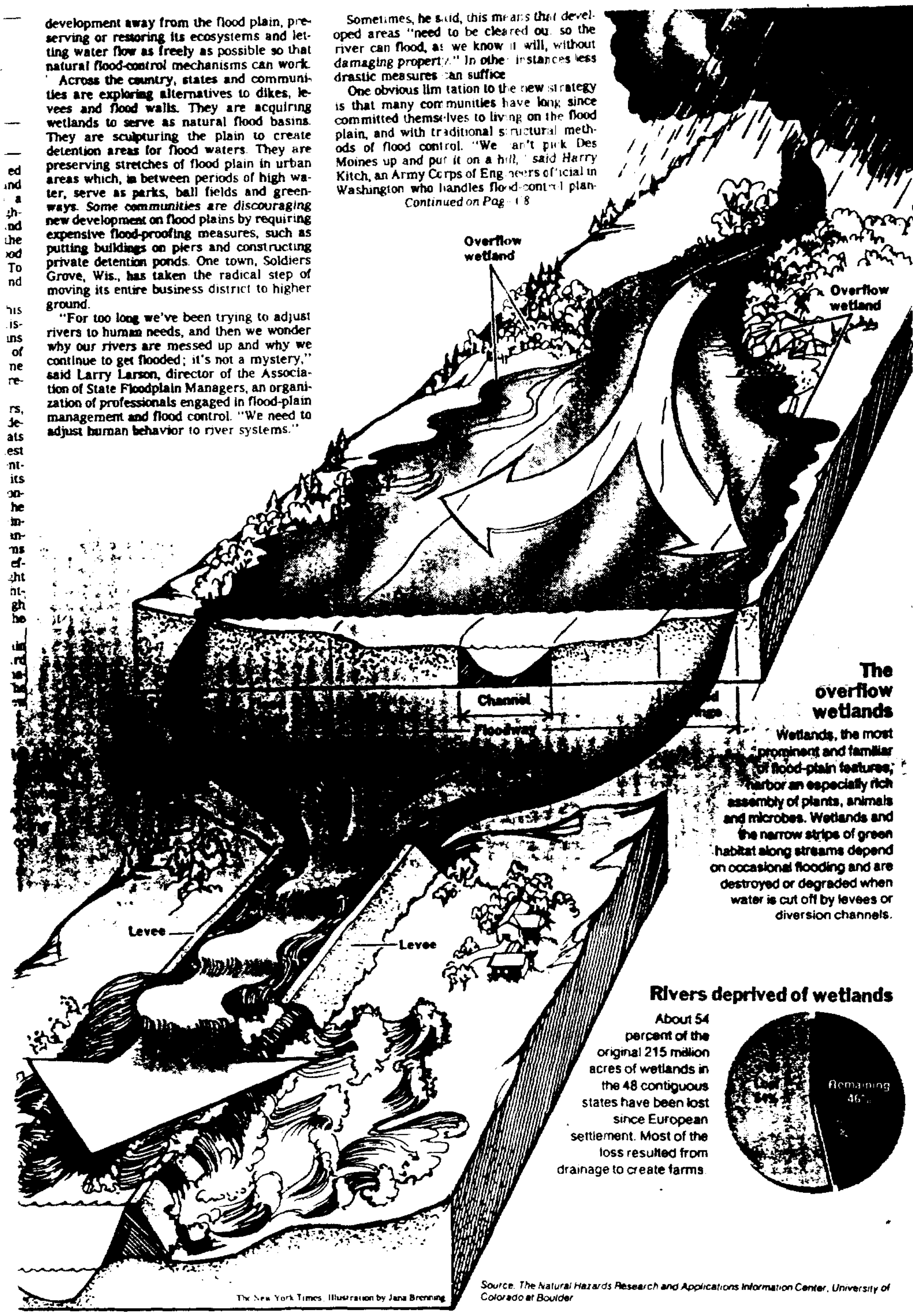
Across the country, states and communities are exploring alternatives to dikes, levees and flood walls. They are acquiring wetlands to serve as natural flood basins. They are sculpturing the plain to create detention areas for flood waters. They are preserving stretches of flood plain in urban areas which, in between periods of high water, serve as parks, ball fields and greenways. Some communities are discouraging new development on flood plains by requiring expensive flood-proofing measures, such as putting buildings on piers and constructing private detention ponds. One town, Soldiers Grove, Wis., has taken the radical step of moving its entire business district to higher ground.

"For too long we've been trying to adjust rivers to human needs, and then we wonder why our rivers are messed up and why we continue to get flooded; it's not a mystery," said Larry Larson, director of the Association of State Floodplain Managers, an organization of professionals engaged in flood-plain management and flood control. "We need to adjust human behavior to river systems."

Sometimes, he said, this means that developed areas "need to be cleared out so the river can flood, as we know it will, without damaging property." In other instances less drastic measures can suffice.

One obvious limitation to the new strategy is that many communities have long since committed themselves to living on the flood plain, and with traditional structural methods of flood control. "We can't pick Des Moines up and put it on a hill," said Harry Kitch, an Army Corps of Engineers official in Washington who handles flood-control plan-

Continued on Page C8



The overflow wetlands

Wetlands, the most prominent and familiar of flood-plain features, harbor an especially rich assembly of plants, animals and microbes. Wetlands and the narrow strips of green habitat along streams depend on occasional flooding and are destroyed or degraded when water is cut off by levees or diversion channels.

Rivers deprived of wetlands

About 54 percent of the original 215 million acres of wetlands in the 48 contiguous states have been lost since European settlement. Most of the loss resulted from drainage to create farms.

The New York Times; Illustration by Jana Brenning

Source: The Natural Hazards Research and Applications Information Center, University of Colorado at Boulder

Satellite A White Elephant, Some Say

Industry spurns an idea it has already found wanting.

By WILLIAM J. BROAD

Special to The New York Times

CAPE CANAVERAL, Fla., July 17 — As the Clinton Administration prods the $70-billion-a-year Federal research complex into doing more to help American business devise new technologies, experts say it should heed the muddle surrounding a $600 million Federal satellite. The craft is expected to be placed into orbit in the next week or so after the delayed mission of the space shuttle Discovery gets off the ground.

The Advanced Communications Technology Satellite, or ACTS, which was under development by NASA for more than a decade, is a 47-foot, high-technology wonder packed with the latest gear. The National Aeronautics and Space Administration hails it as the first of a new generation of lightning-fast communications craft for the 21st century.

That may be the case. But so far the celestial experiment has generated little or no interest among its main targets — American satellite builders, who say its gadgetry is either irrelevant to their needs or coming along far too late to be of any use.

Industry giants like Hughes, TRW and Loral, which collectively dominate the world market in communications satellites, have all ignored ACTS, which is available to would-be experimenters at no charge. Those who have signed up to test the spacecraft and its features are academic and governmental experts as well as companies on the fringes of the satellite industry.

Private analysts say ACTS is a case study in Federal myopia. They note that the craft was planned just as the rising attractiveness of fiber-optic cables on the ground began to bring much of the telecommunications industry crashing back to Earth.

More generally, many economists say Federal officials lack the knowledge to predict what technologies will succeed in the marketplace and are never canny with taxpayer money, unlike entrepreneurs who risk their own. Such defects, they say, make Federal industrial policies all too prone to producing white elephants.

Officials of the space agency vigorously defend ACTS, saying that its experiments are important and represent the kind of futuristic risk-taking that only governments can afford. The craft has attracted few major players from industry, they say, because its rocky history of ups and downs in financing slowed its development and frightened away poten-

Continued on Page C6

SCIENTIST AT WORK

Jimmie Holland

Listening to the Emotional Needs of Cancer Patients

By ELISABETH ROSENTHAL

FOR a time in the early 1970's, conversations between Dr. Jimmie Holland, a leading psychiatrist, and her husband, Dr. James Holland, a leading cancer specialist, often took a familiar [illegible]

how do they feel?" — into the first psychiatry service at Memorial Sloan-Kettering Cancer Center, the country's largest training program in psychiatric oncology and, ultimately, into the emergence of psycho-oncology as a new field.

For the past 17 years she has conducted tireless research about how battles with cancer affect the mind: How does body image [illegible] removal of a breast [illegible]

"We still get a lot of people saying: 'Of course she's depressed. She's got cancer. Who wouldn't be?' " she lamented. "But we have learned that most people with cancer are sad but don't have true depression. And when they do, it can be treated."

Twenty years ago, the prognosis for cancer patients was so grim that the few therapists who worked with them focused solely on death and dying. Patients who survived a few [illegible]

NASA's Communications Satellite Seen by Some as White Elephant

Continued From Page C1

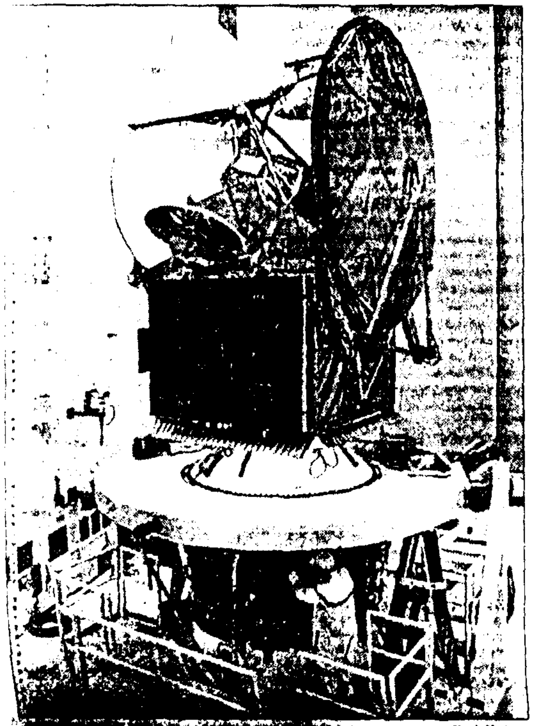
[illegible]ial users.

"People were never sure we were real, because of funding cutbacks," said Rodney M. Knight, an ACTS manager at NASA's Lewis Research Center in Cleveland. "But I think they see we're real now and will get involved. They cannot afford to lose the business edge."

The spacecraft has 71 experiments so far, Mr. Knight said, noting that there was still limited room for serious proposals. Some existing tests by NASA centers appear to be rather frivolous and are perhaps there simply to fill up vacancies. In contrast, NASA scientific satellites like the Hubble Space Telescope or the Compton Gamma Ray Observatory usually attract a large surplus of experimental proposals.

"It's lemon socialism," said John E. Pike, head of space policy at the Federation of American Scientists, a private group in Washington. "With ACTS, the Government is funding stuff the market has rejected. It's a case study in how Federal efforts to enhance American competitiveness can go awry."

The tribulations of the project are seen as a vivid lesson for the Clinton Administration, which came into office pledging to shift tens of billions of dollars from Federal programs that forge armaments into ones that foster civil industries. The Administration's aim is to flood the economy with innovative goods and services, lifting the general level of prosperity and strengthening American industry for international trade wars.



The seeds of the project were sown in the late 1970's as the space agency predicted rapid growth of the satellite communications industry. Such craft sit mainly in 22,300-mile-high orbits that are stationary relative to Earth's surface. From those geosynchronous orbits, they relay signals around the globe. To eliminate projected crowding on frequencies used to transmit signals, NASA proposed an experimental craft, ACTS, that would operate in the virgin territory of higher frequencies.

The tactic was a common one. The 20th century has seen radio, television and satellite broadcasts all march up the electromagnetic spectrum to ever-higher frequencies. The expansion is hard to achieve technically but offers great rewards, since higher frequencies can transmit far greater amounts of information.

Satellites normally use the C band, at 4 and 6 gigahertz, and the Ku band, at 11 and 14 gigahertz. A hertz is a unit of frequency equaling one cycle per second. A gigahertz is a billion hertz. A radio wave at the frequency of a gigahertz vibrates so rapidly that, while moving past a stationary point, it goes through a billion up-and-down cycles a second.

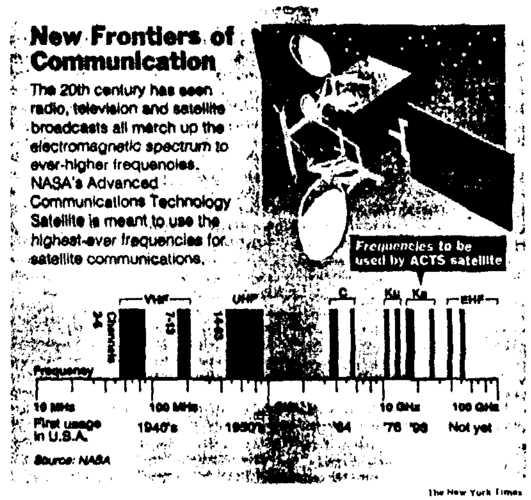
What NASA envisioned was a satellite operating in the Ka band, at 20 gigahertz and 30 gigahertz. This electromagnetic wilderness has 2.5 gigahertz of spectrum available, or five times what is used by conventional satellites at lower frequencies. It is, electromagnetically at least, wide open for exploitation.

The high frequencies used by the satellite can be scattered by raindrops.

The higher frequency also meant ACTS could use smaller ground stations, as permitted by the laws of electromagnetic coupling. The antennas could be four feet across and possibly smaller.

Rain as an Obstacle

The substantial risk in all this was rain. High-frequency signals [illegible] showers, while lower frequency signals blast right through to geosynchronous orbit and back again. The higher the frequency, the greater the risk. The daunting challenge to ACTS was to find ways to eliminate rain fade, otherwise no company would ever want to use the Ka band for geosynchronous satellites, given the prospect of constant interruptions.



The New York Times

"ACTS is to do hands-on experiments with this attenuation and techniques for combating it," said Mr. Knight of NASA. "We may not solve the problems completely, but we'll understand them far better. And we think that's a valuable resource for future satellite-system designers."

But industry officials faulted most of NASA's analyses, even as ACTS gained momentum in the late 1970's and early 1980's. In May 1980, Dr. Arno Penzias, a Nobel laureate at A.T.& T. Bell Laboratories, told the House science committee that A.T.& T. had investigated the rain-fade problem of the Ka band on its Comstar satellites at its own expense.

"We don't like what we see," he said. Indeed, A.T.& T. dropped plans to use the Ka band because of that problem, because of the expense of developing the new technology and, most important of all, because it saw no need for new transmission bands given the increasing use of fiber-optic cables and new ways to pack more signals into existing frequencies.

The Federal Communications Commission, which assigns transmission frequencies, agreed, telling Congress in 1980 that crowding arguments were "largely subjective and based on little analysis."

Despite such appraisals, ACTS found favor with Congressional pa[illegible] worried about America's [illegible] attacks by the free-market enthusiasts of the Reagan Administration failed to stop it, although its budget zigged and zagged over the years. In 1984, Dr. George A. Keyworth 2d, the Presidential science adviser, said that he could "not understand why the Federal Government should expend funds to demonstrate 20-30 gigahertz technology when industry has an enormous profit incentive."

Despite its critics, the satellite found favor in Congress.

As ACTS moved ahead by fits and starts, always teetering on the brink of extinction, foreign governments launched their own Ka-band test satellites faster than NASA. "Japan and Europe have spent an enormous amount of money on this and nobody knows what it's good for," Mr. Pike said.

So too, the ACTS program has experienced a hard time signing up experiments since it began soliciting them in 1985. Today the tests consist of a hodgepodge of the serious and not-so-serious. American Express will relay data between its sites in Phoenix and Mexico City. Ohio University will help the Huntington Bank of Columbus, Ohio, relay data to one of its check processing centers in a suburb of Cleveland.

NASA's Kennedy Space Center here in Florida plans a video link with a California center to train employees in handling hazardous materials. [illegible] Houston will relay interior images of the human eyeball to test remote medical diagnosis.

NBC will relay images from remote news-gathering sites. The Communications Satellite Corporation of Washington, a major participant in the communications business and an ACTS contractor, will test the general system.

And the NASA Lewis Research Center, the home of ACTS, will perform a bevy of tests to see how well the whole thing works in the rain.

Mr. Knight of the Lewis center said ways to fight rain attenuation included coding schemes that reconstructed lost data, power boosting that blasted through rain clouds, and geographically separating earth stations, to lower odds of rain interruption.

In a news release on ACTS, NASA said, "Technology spinoff is already occurring" and named a company, Norris Communications, that it said was preparing to build a Ka-band communications satellite. But there are some doubts about the seriousness of this action.

Based in Red Lion, Pa., Norris Communications is a small company owned by John H. Norris, who also runs local radio and television stations there, as well as the Keystone Inspirational Network. According to Gordon Moul, a company salesman, Keystone, which is now distributed by rented satellite,is "a religious-Christian program source for cable-TV stations interested in family programming."

Neither Mr. Moul nor anyone else reached at the company knew when the satellite might be built or launched. Attempts to reach Mr. Norris were unsuccessful.

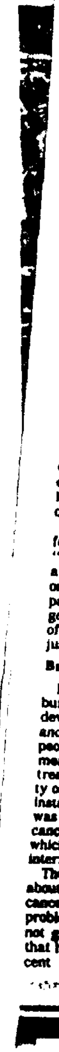
Commercial satellite builders do have some interest in the Ka band, but not where ACTS is testing it, 22,300 miles above Earth. In much lower orbits Ka-band signals are powerful enough to cut through rain clouds without fancy equipment or techniques. Thus, Motorola, which has no experience building whole satellites, is eyeing the Ka band for operating some aspects of its proposed Iridium system of global wireless telephony. The Iridium satellites are to fly in orbits 483 miles high.

Company's Lack of Interest

Montye Male, public affairs director for the TRW Space & Electronics Group, based in Redondo Beach, Calif., said TRW had investigated the Ka band on its own and had no interest in doing experiments on ACTS, even though access was free.

"Why invest the time when you think you've done a lot of research on your own?" she asked.

Analysts say a moral of the ACTS story is that Government should tread very gingerly when it tries to help industry technically and that any aid programs that do materialize should be structured so that businesses pay a substantial part of the costs, creating an opening for the discipline of market mechanisms. Otherwise, they say, the white elephants are like[illegible]



Emotional N[illegible]

Continued From Page C1

an whose 85 years have included some unusual twists and turns. An only child, born to parents who never finished high school, Jimmie Coker grew up on a farm in Nevada, Tex., where she loved taking care of animals. When she graduated from high school — in a class of eight — she planned to become a nurse. "But then I figured out I could be a doctor," she recalled.

After graduating from Baylor University in Waco, she went to Baylor's medical school in Houston, where her class of 80 had "three women, three Jews — the usual quota in Texas" at that time, she said. Although she initially planned to take care of patients' physical problems, she quickly shifted course. "I decided the most interesting thing was not the biochemistry of congestive heart failure, but the psychological and social issues surrounding it," she said. "How do people cope with adversities in life? The best common denominator [illegible] this is illness." Although she [illegible] worked with patients suffering [illegible] diverse diseases, after her marriage in 1956, her interest gradually shifted to the psychology of cancer.

Dr. Holland listened to her [illegible]gist husband talk about the emotional problems of cancer patients [illegible] years, as she worked part time while raising their five children. When she returned to full-time work in the mid-1970's, she knew where to focus. In 1977 she and two of her students [illegible] started the division of psychiatry at [illegible] Memorial Sloan-Kettering Cancer Center, one of the nation's leading cancer hospitals, which had previously had only a half-time psychologist on staff.

"When I started, I was in a [illegible] foreign environment," she recalled. "Few of the medical staff [illegible] around. First I had to prove to [illegible] oncologists that we could help [illegible] patients — before they were [illegible] go to a psychiatric hospital [illegible] off the roof. But [illegible] just began to grow."

Breaking New Ground

Dr. Holland [illegible] build the field [illegible] developing [illegible] and treating [illegible] people with [illegible] measuring [illegible] treatments [illegible] ty of life. They [illegible] instance, how [illegible] was in patients [illegible] cancers. And they [illegible] which psychiatric [illegible] interfere with [illegible]

They have since [illegible] about a quarter of [illegible] cancer have significant [illegible] problems, although [illegible] not get help. Dr. [illegible] that her staff now [illegible] cent of all inpatients [illegible]